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The Cost of Not Wearing Seat Belts

A Comparison of Outcome in 3396 Patients

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Data from the North Carolina Trauma Registry were analyzed to determine the effect of seat belt usage on outcome in motor vehicle accidents. Of 6237 persons involved in motor vehicle accidents, data on seat belt usage were available for 3396. Of these, 1916 were not and 1480 were wearing seat belts. The mean hospital charge in belted patients was $10,500 +/− $18,200; and in unbelted patients, $15,250 +/− $26,300 ($p < 0.001$). The total hospital charges were $23 million for the 1508 patients not wearing seat belts. If the unbelted patients had outcomes similar to belted patients, the charges resulting from caring for the 1508 patients would have been $15.8 million, a potential savings of $7.2 million. There were 135 deaths among the unbelted patients (7.0%) and 47 deaths among the belted patients (3.2%) ($p < 0.001$). A similar projection of belted outcome for unbelted patients suggests that seat belt usage could have reduced the unbelted mortality rate by over one half. Patients wearing seat belts also had significantly shorter hospital stays, fewer days in the intensive care unit, and fewer days on the ventilator ($p < 0.001$). Seat belt usage is associated with a significant decrease in mortality rate, hospital charges, length of stay, intensive care unit stay, and ventilator requirements. Seat belts could have saved at least 74 lives and 7.2 million dollars during the period from October 1, 1987 to July 1, 1989 in patients seen in the seven trauma centers in North Carolina.

Motor vehicle crashes cause nearly 45,000 deaths and more than 3.2 million injuries each year.[1] Although seat belts are known to decrease the morbidity and mortality rates of motor vehicle crashes,[2,3] the use of seat belts remains far from universal. This is demonstrated by the fact that the use of seat belts by drivers in North Carolina, 1 year after passage of a mandatory seat belt law, was only 64%.[4]

The purpose of this study was to review data from the North Carolina Trauma Registry (NCTR), a cooperative group of the eight trauma centers in North Carolina, in order to analyze the association of seat belt use and patient outcome. Our hypothesis was that unbelted patients have more severe injuries, have a higher mortality rate, and use more health care resources. The characterization of the increased hospital charges, injury severity, and mortality rate can be useful to further public health measures aimed at reducing the morbidity rate, mortality rate, and costs of motor vehicle crashes.

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METHODS

A cooperative effort in North Carolina among the eight designated trauma center hospitals, the four medical schools, the North Carolina Department of Human Resources, the North Carolina Governor's Highway Safety Committee, and the Office of Emergency Medical Services has resulted in the formation of the North Carolina Trauma Registry.[5]

The North Carolina Trauma Registry (NCTR) is a database system that includes all eight designated level I and level II trauma centers in North Carolina: Charlotte Memorial Hospital, Duke University Medical Center, Moses Cone Memorial Hospital, North Carolina Baptist Hospital, University of North Carolina Hospitals (formerly North Carolina Memorial Hospital), New Hanover Memorial Hospital, Pitt County Memorial Hospital, and Wake Medical Center. Data collection began on October 1, 1987, and as of July 1, 1989 data have been entered on 16,436 trauma patients.

The NCTR includes all patients admitted to the hospital for at least 1 day, as well as all patients declared dead in the emergency department. Data on trauma patients were entered into a database using a microcomputer at each hospital, and at intervals these data were sent to the central collection agency at the University of North Carolina at Chapel Hill. Data were validated on entry by the trauma registrar and the physician staff at each hospital. Trauma patients included in the NCTR were defined as patients with the International Classification of Diseases Supplementary Classification of Diagnosis (ICD-9-CM) codes between 800 and 959.9. Abbreviated Injury Scale (AIS) and Injury Severity Scores (ISS) were derived from the patient's ICD-9 Diagnosis Codes using the method developed by Ellen MacKenzie.[6]

This study was limited to patients admitted after automobile crashes for whom seat belt use data was available. Two distinct populations, belted patients and unbelted patients, were then compared using chi squared tests for categorical data and Student's t tests for continuous data. Statistical analysis was completed on a microcomputer using SAS Institute software (SAS).

RESULTS

Of 16,436 patients included in the NCTR, 15,989 had ICD-9-CM Etiology Codes, providing information on the cause of the injury. Of this group, 6,237 (40.9%) of these were caused by motor vehicle crashes. Seat belt data were available for 3396 (54.4%). Of the group with seat belt information, 1480 (43.6%) were reported as wearing seat belts and 1916 (56.4%) were reported as not wearing seat belts. Table 1 provides a summary of the variables studied for belted *versus* unbelted patients.

Demographics of Seat Belt Use (Age, Race, Day, and Time of Admission)

The average age of the 1916 unbelted patients was 30.3 ± 16.7 years. The average age of the 1480 belted patients was 36.9 ± 18.8 ($p < 0.0001$). The largest numbers of crash victims were aged 10 to 39 years. These patients also had the lowest rate of seat belt use (range, 28% to 54%). Patients older than age 50 used their belts more often (range, 41% to 72%). White women older than age 50 were most likely to wear belts (range, 62% to 72%) whereas white men ages 10 to 29 were least likely to wear belts (range, 28% to 29%). On the whole, women had higher seat belt usage rates than men, 50.2% to 39.3%, respectively.

Unbelted patients were more likely to be involved in crashes that occurred on weekends (Friday, Saturday, or Sunday), and in crashes that occurred at night (between 7:00 P.M. and 7:00 A.M.).

Alcohol

Of the 1916 unbelted motor vehicle crash victims, 406 (21.2%) had blood alcohol levels of greater than 100 mg/dL. The mean alcohol level (mg/dL) of those who were not belted and had been drinking was 157 ± 93. Of the 1480 belted patients, 130 (8.8%) had alcohol levels greater than 100. The mean alcohol level of those who were belted and had been drinking was 136 ± 86 ($p = 0.0057$). Table 2 summarizes those data.

Injury Severity

Scene Trauma Scores were available in 1099 patients (643 unbelted and 456 belted). The mean trauma score at the scene in unbelted patients was 13.2 ± 3.5 as compared with 14.6 ± 2.4 in belted patients ($p < 0.0001$). Emergency Department (ED) Trauma Scores were available in 2936 patients. The mean ED trauma score of those not wearing seat belts was 14.0 ± 3.3, and in those wearing seat belts the trauma score was 15.1 ± 2.15 ($p < 0.0001$). The mean Glasgow Coma Scale of those not wearing seat belts was significantly worse in unbelted patients (12.7 *versus* 14.0 ± 2.7; $p < 0.0001$). The number of units of blood transfused within 24 hours of injury was greater in unbelted patients (1.6 ± 4.2 in unbelted *versus* 1.2 ± 3.1 in belted patients; $p = 0.03$).

Abbreviated Injury Scale (AIS) for each body system and Injury Severity Score (ISS) were computed as derived from the patient's final ICD-9 Diagnosis Codes using the method of MacKenzie et al.[6] Analysis of the incidence of head injury as calculated by AIS scoring showed that 44.5% of unbelted patients had some form of head injury, as compared with 32.9% of those wearing seat

Table 1. SUMMARY OF VARIABLES FOR BELTED *VERSUS* UNBELTED PATIENTS

	With Seat Belt		Without Seat Belt		
Category	Mean	SD	Mean	SD	p
Age	36.9	18.8	30.3	16.7	<0.0001
Scene trauma score	14.6	2.4	13.2	3.5	<0.0001
Emergency department trauma score	15.1	2.15	14.0	3.3	<0.0001
Revised trauma score	11.6	1.18	11.4	1.51	0.0065
Blood pressure	127	28	123.6	28	0.005
Glasgow coma scale	14.0	2.7	12.7	3.9	<0.0001
Hematocrit	38.7	6.0	38.5	6.8	0.299
Units of blood transfused	1.2	3.1	1.6	4.2	0.0317
Ethanol (mg/dL)	136	86	157	93	0.0057
AIS					
Face	0.31	0.75	0.34	0.71	0.33
Head/neck	0.9	1.43	1.36	1.7	<0.0001
Soft tissue	0.48	0.58	0.51	0.63	0.0904
Chest	0.88	1.34	0.87	1.39	0.94
Abdomen	0.47	1.03	0.43	1.01	0.33
Extremities	1.07	1.24	1.09	1.255	0.67
ISS	10.6	8.62	12.9	10.85	<0.0001
Ventilator (days)	2.0	6.9	3.2	7.6	0.0028
Intensive care unit	3.5	7.2	5.1	9.3	<0.0001
Hospital (Days)	10.5	15.3	13.2	19.4	0.0001
Hospital charges ($)	$10,500	$18,200	$15,250	$26,300	<0.0001

SD, standard deviation; AIS, abbreviated injury scale; ISS, injury severity scale.

belts ($p < 0.001$). The mean AIS score for head and neck injuries was 1.36 ± 1.7 for those without seat belts as compared with 0.9 ± 1.43 in those wearing seat belts ($p < 0.0001$). There was no significant difference in the AIS scores for the other body systems in the belted and unbelted groups. The mean ISS for those not wearing seat belts was 12.9 ± 10.85 and 10.6 ± 8.62 in belted patients ($p < 0.0001$).

Intensive Care Unit, Hospital Stay, and Hospital Disposition

The mean number of days on a ventilator, mean number of days in the Intensive Care Unit (ICU), and mean number of days in the hospital were compared. The mean number of days on a ventilator in those not wearing seat belts was 3.2 ± 7.6 as compared with 2.0 ± 6.9 in those wearing seat belts ($p = 0.0028$). The mean number of ICU days was 5.1 ± 9.3 in those not wearing seat belts and 3.5 ± 7.2 in those wearing seat belts ($p < 0.0001$). Length of total hospital stay was available for 2923 patients. The mean hospital stay for unbelted patients was 13.2 days ± 19.4 compared with 10.5 days ± 15.3 in those wearing seat belts ($p = 0.0001$).

The number of belted patients requiring rehabilitation facilities (3.5%), was significantly less than in the unbelted group (6.9%) ($p < 0.001$). Only 68% of the unbelted patients were discharged home compared with 77% of the belted patients ($p < 0.001$).

Table 2. ALCOHOL USE BY ALL MOTOR VEHICLE ACCIDENT CRASH VICTIMS

	Average Etoh (mg/dL)	No. of Patients (% of n)		
		Alcohol > 0	Etoh < 100	100 < Etoh
Unbelted (1916)	157	569 (29.7%)	160 (8.4%)	406 (21.2%)
Belted (1480)	136	214 (14.5%)	82 (5.5%)	130 (8.8%)

Etoh, ethanol.

Insurance

Insurance information was available for 3245 patients (96%), 1826 unbelted and 1419 belted. Of the 1826 unbelted patients, 746 (41%) had no insurance, 577 (32%) held commercial policies, 228 (13%) were insured by Blue Cross Blue Shield, 111 (6%) were insured by Medicare, and 60 (3%) were insured through Medicaid. In the belted group, 397 (29%) were not insured, 478 (35%) held commercial policies, 214 (16%) were insured by

Blue Cross Blue Shield, 157 (11%) were insured through Medicare, and 42 (3%) were insured through Medicaid. Significantly more unbelted patients are uninsured (41%) than belted (29%) ($p < 0.001$).

Financial Charges

The mean hospital charge, not including professional fees, for patients wearing seat belts was \$10,500 ± \$18,200 compared with \$15,250 ± \$26,300 for those not wearing seat belts, a difference of \$4750 ($p < 0.0001$). The total cost to care for the 1206 belted patients with available charge data was \$12.7 million. The total cost to care for the 1508 patients who did not wear seat belts was \$22.99 million.

Mortality Rate

There were 47 deaths in 1480 patients (3.2%) who wore seat belts and 135 deaths in 1916 patients (7.0%) not wearing seat belts ($p < 0.001$).

DISCUSSION

The purpose of this study was to describe the outcome of motor vehicle crashes in belted and unbelted patients entered into the North Carolina Trauma Registry for whom seat belt data was available. This database represents trauma admissions to all level I and level II Trauma Centers in North Carolina. The North Carolina Trauma Registry is not a population-based registry and, as others have emphasized, cannot be used to draw conclusion about all seat belt users in this state.[7,8] There are many problems using data derived from trauma centers. The data may not be representative of North Carolina as a whole for a number of reasons. The eight trauma centers making up the Trauma Registry are major referral centers for large areas of the state and therefore see many of the most severely injured patients. Most of the trauma centers are also located in urban areas. The large, sparsely populated, western part of the state is underrepresented because there is no major designated trauma center in that area. The mortality rate is typically higher in areas with low population density.[9]

There are also biases present as a result of the selection criteria used to determine which patients will have data entered into the registry. For example, victims that die at the scene do not reach the emergency department and are not included in the registry. Also, because the Trauma Registry contains only patients admitted for more than 24 hours, those patients who are minimally injured, treated in the emergency department, and then released, are not included in the database.

Another important feature is that the NCTR works in a production environment to address a variety of objectives: (1) provide monitoring of care, (2) estimate costs, (3) determine manpower needs, (4) define variables on which mortality and morbidity rates depend, (5) determine risk factors for accidental events, (6) provide quality assurance information for the hospital trauma system, and (7) produce resource utilization information. Our data are collected from patient reports and medical records, and studies have shown that patients may not always be truthful about their use of belts.[10] Despite these limitations, the NCTR provides a valuable database for analysis of information on injured patients and their outcome.

Motor vehicle passenger death and injury are reduced by the use of seat belts.[11,12] At least 37 countries have a collective experience with seat belt use laws. With the exception of Great Britain, where compliance rates are about 95%, the usual pattern involves considerable increase in belt use with passage of mandatory restraint law followed by a gradual decrease with increases during enforcement activity. Rates of death and injury are reduced after law enforcement of belt use.[13,14] A number of recent articles elaborate experience with seat belt legislation.[15] In North Carolina, projections of 1,100 severe or fatal injuries saved per year were attributed to the seat belt law, where use rose to 78% and remained in the 60% to 65% range.[16] Orsay et al.[17] in Chicago and Bernstein et al.[18] in Albuquerque assessed seat belt law impact on specific injury demographics, including patterns, injury severity, and cost from emergency department databases.[17,18]

The outcome of drivers in motor vehicle crashes cannot be compared on the basis of one variable alone, such as seat belt use. The analysis should be multivariate so as to uncover the relative contributions of several possible variables on the outcome measured. These confounding variables such as age of the patient, speed, and type of the crash may offset the outcome in either a positive or negative way. Most important is the fact that the severity of the crash modifies the severity of the injury. The unbelted driver is more likely to be younger, male, and drinking. Our data show that the unbelted patient is more likely to be injured in crashes that occur at night or on weekends. Other studies show that the unbelted driver is more likely to be involved in a high-speed crash.[19] Each of these variables could modify the outcome of the crash and the occupants' injuries. Unfortunately, the NCTR does not have data on the severity of the crash, so such an analysis controlling for the seriousness and the type of crash was not possible.

Demographics of Seat Belt Usage (Age, Race, Day, and Time of Admission)

This study demonstrates, as have others, that patients younger than age 39 are less likely to be belted. This age group also makes up the largest portion of the injured. Prevention should be directed actively at the individuals younger than age 39, for it is this group that makes up the majority of motor vehicle trauma and is least likely to wear seat belts. White women older than age 50 were most likely to wear seat belts (range, 62% to 72%) whereas white men ages 10 to 29 were least likely to wear belts (range, 28% to 29%). On the whole, women had higher seat belt usage rates than men, 50.2% to 39.3%, respectively.

Alcohol

Alcohol remains an important cause of all motor vehicle crashes. Unbelted patients were more likely to be intoxicated than belted patients (29% *versus* 14%). Mean blood alcohol values were significantly higher in unbelted patients ($p = 0.0057$). Twenty-one per cent of unbelted patients had a blood alcohol level greater than 100 mg/dL compared with only 8.8% of the belted. Even in belted patients, a significant proportion of crashes (14.5%) are related to alcohol (Table 2).

Injury Severity

The scene and emergency department trauma scores, and the Glasgow Coma Scale were all significantly lower for the unbelted patients, demonstrating the increased severity of injury in unbelted patients. An important piece of information missing from our data is the nature and seriousness of the crash. Because we know that unbelted occupants are involved in more serious crashes, this precludes us from concluding that seat belts alone cause this increased severity of injury. Head injury was more common and more severe in unbelted drivers. This is important because head injury is the one of the major killers of trauma patients. ISS scores were higher in unbelted patients primarily because of the increased severity and frequency of head injury. Seat belt use was not associated with a significantly decreased severity of injury in other body systems.[20]

Intensive Care Unit, Hospital Stay, and Hospital Disposition

Unbelted victims spent significantly more days on ventilators, more days in the ICU, and more total days in the hospital. A significantly higher percentage of unbelted patients are transferred to rehabilitation facilities. The NCTR database does not collect long-term follow-up data, but postinjury rehabilitation hospital care is expensive, and this adds to the human and financial loss associated with not wearing seat belts.

Insurance

Forty-one per cent unbelted as opposed to 29% belted victims have no source of insurance. This represents a major nonreimbursable cost for which the health care system and society is liable. This also puts a proportionally greater financial strain on trauma centers, because they treat more seriously ill patients and more uninsured patients. Disability is significantly more severe in unbelted patients, which implies that the long-term costs from the loss of work will be greater in unbelted patients.

Financial Charges

The total hospital charges in these two groups of patients represent huge societal expenditures. Unbelted drivers had mean hospital charges that were 50% higher than belted patients. The total charges for unbelted patients were $23.0 million *versus* $12.7 million for belted patients. Again, because the severity of the crashes in the two groups is unknown, we cannot compare the charges in the two groups. Nevertheless, if the unbelted patients had been wearing seat belts and if they had incurred hospital charges similar to those of belted patients, seat belt usage could have resulted in a savings of $7.2 million in these eight hospitals over a period of 21 months. If we extend this projection to the total number of patients involved in motor vehicle crashes (6237 patients), the projected total hospital charges for unbelted patients drops from a total of $53.6 million to $36.97 million, a potential savings of $16.7 million. The projected savings of $16.7 million, if the unbelted had been belted for this 21-month period in the eight participating trauma centers, is staggering. Even this large figure understates the resource savings. Although many groups argue against enforcing seat belt laws because of the issue of personal freedom, it can be demonstrated here that there is a huge cost to society by allowing this freedom.[21]

Mortality

The mortality rate was significantly higher in unbelted patients (7.05%) than in belted (3.18%). Other studies have shown reductions of 9% in motor vehicle fatality.[22] Given the same caveats as stated above, we estimated that if the unbelted patients had been wearing seat belts, and if this had in turn resulted in a mortality rate similar to the belted group, 74 lives might have been saved in a 21-month period.

CONCLUSION

Although wearing seat belts should be an obvious and universally employed method to decrease the morbidity and mortality risk of motor vehicle crashes, it remains underused. The purpose of this study was to analyze data from the North Carolina Trauma Registry to characterize the outcome of belted and unbelted patients after motor vehicle crashes. We confirmed the association of seat belt use with a decreased severity of injuries, a decreased mortality rate, and a decreased utilization of hospital resources. As others have shown, our data demonstrate that use of seat belts is associated with a marked reduction in the morbidity and mortality rates of associated motor vehicle trauma.

References

1. Committee on Trauma Research, Commission on Life Sciences, National Research Council and the Institute of Medicine, Grossblatt N, ed. Injury in America. Washington, DC: National Academy Press, 1985.
2. Cunningham JW, Wilson FR. Injury patterns for occupants of small trucks. Accid Anal Prev 1989: 21(2):105–113.
3. Campbell BJ. Safety Belt Injury Reduction Related to Crash Severity and Front Seated Position. Chapel Hill, North Carolina: North Carolina Highway Safety Research Center (HSRC), 1984.
4. Reinfurt DW, Campbell BJ, Stewart JR, et al. North Carolina occupant restraint law: a three year evaluation. North Carolina Highway Safety Research Center: October 1988, Executive Summary, p V.
5. The North Carolina Trauma Registry is funded by the Governor's Highway Safety Program through the North Carolina Office of Emergency Medical Services, Department of Human Resources.
6. MacKenzie EJ, Steinwachs DM, Shankar BS. An ICD-9CM to AIS Conversion Table: development and application. Proceedings of the American Association for Automotive Medicine, 1986, p 135.
7. Payne SR, Walter JA. Trauma registry and trauma center biases in injury research. J Trauma 1989; 29:424–429.
8. Waller JA. Methodologic issues in hospital based injury research. J Trauma 1988; 28:1632–1636.
9. Baker SP, Whitfield RA, O'Neill B. Geographic variations in mortality from motor vehicle crashes. N Engl J Med 1987; 316(22): 1384–1387.
10. Comparison of observed and self-reported seat belt use rates—United States. MMWR 1988; 37(36):349–351.
11. Vaage T. Safety belt usage laws in various countries: Ineffectiveness of safety belt use laws: a multinational examination. US Deparment of Transportation Publication HS-807-018, Washington, DC: National Highway Traffic Safety Administration, 1986.
12. McGee DL, Rhodes P. Estimating trends in the effectiveness of seat belts in saving lives, 1975–1985. Stat Med 1989; 8(3):379–385.
13. Barancik JI, Kramer CF, Thode HC, et al. Efficacy of the New York State seat belt law: preliminary assessment of occurrence and severity. Ball NY Academy Med 1988; 64(7):742–749.
14. Marburger EA, Friedel B. Seat belt legislation and seat belt effectiveness in the Federal Republic of Germany. J Trauma 1987; 27(7):703–705.
15. Petrucelli E. Seat belt laws: the New York experience: preliminary data and some observations. J Trauma 1987; 27(7):706–710.
16. Chorba TL, Reinfurt DE, Hulka BS. Efficacy of mandatory seat belt use legislation. JAMA 1988; 260(24):3593–3597.
17. Orsay EM, Turnbull TL, Dunne M, et al. Prospective study of the effect of safety belts on morbidity and health care costs in motor vehicle accidents. JAMA 1988; 260(24):3598–3603.
18. Bernstein E, Pathak D, Rutledge L, et al. New Mexico safety restraint law: changing patterns of motor vehicle injury, severity and cost. Am J Emerg Med 1989; 7(3):271–277.
19. Robertson LS. Public perception and behavior in relation to vehicle passenger restraints. *In* Covello VT, Flamm WG, Rodricks JV, Tardiff RG, eds. The Analysis of Actual Versus Perceived Risks. New York: Plenum Press, 1983, pp 11–22.
20. Greenberg SR. Seat belts and human rights: an appraisal. J Forensic Sci 1987; 32(1):158–166.
21. Raisis LW. Helmet and seat belt laws, private or public choice. Del Med J 1989; 61(6):303.
22. Lund AK, Pollner J, Williams AF. Preliminary estimates of the effects of mandatory seat belt use laws. Accid Anal Prev 1987; 19(3):219–223.